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Water Balance of Horses Fed Various Diets

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TECHNICAL REPORT: WATER BALANCE OF HORSES FED VARIOUS DIETS

ABSTRACT

Water balance was evaluated retrospectively in horses and ponies fed grass hays, legume hays and complete pelleted diets in which the main ingredient was legume hay, cereal hay or grain. Data was used from eight digestion studies which evaluated 39 feeds. Water intake depended on dry matter (feed) intake or fiber intake. When fed long, hay type did not affect water intake but pelleting the ration reduced water intake by horses. The route by which ingested water was excreted depended on diet type. Thus, water was excreted mainly (55% of water consumed) through manure or feces when grass hays were fed but urine was the main route of excretion (44 to 56%) when legume hays or complete pelleted diets were fed. Urine output depended on the amount of water consumed, the amount of water excreted in feces, and the crude protein intake. Insensible water losses, i.e. respired and perspired, were estimated to be 14 to 24% of total water consumption.

BACKGROUND AND OBJECTIVES

Water balance in horses is based on consumption (free, feed and metabolic water) and excretion (feces, urine, respired or cutaneous). Free water represents 86% of total water intake and varies from 6.2 to 6.4 liters/100 kg body weight (BW) daily for idle horses kept indoors at moderate temperatures and fed hay diets. However, water intake varies with climate, level of activity, physiological state and diet. Few controlled studies have examined how diet or nutrient content affect water intake and excretion by horses. Dry matter (DM) digestibility and intake, cell wall and ash content of the diet are reported to modify water balance in horses. Generally most of the data

relating diet to water balance of horses has been anecdotal. Thus, legume hays such as alfalfa are thought to contribute to excess urine production while overmature, fibrous grass hays or cereal straws are believed to constipate horses especially when insufficient water is given.

The objectives of this study were to examine the dietary effects on measurable water balance of the horse.

EXPERIMENTAL PROCEDURE

Data from eight separate digestion trials were used in which 39 different diets were evaluated. Initially, feeds were categorized into two groups, unpelleted or pelleted, but were further sub-classified as feeds with or without protein and/or mineral supplementation. Non-pelleted feeds included non-supplemented cereal, grass and legume hays. Because the cereal and grass hays were alike in composition and did not differ statistically in analysis of water balance, data for these feeds were pooled and were classed as a single group called grass hays. The grass hays included three bromegrasses, three oats, two crested wheatgrasses, one each of reed canarygrass, Altai wildrye, Kentucky bluegrass, and slough hays. Pelleted, non-supplemented legume hays were similar in composition and water balance response to unpelleted legume hays. These data were also pooled and this group was called legume hays. One sweet clover and six alfalfa hays comprised this group. Two types of supplemented pellets were evaluated: those in which the main ingredient was forage (>75%) or grain (>55%). Pelleted forage diets were further sub-divided on the basis of forage component: alfalfa or cereal hay. The final diet categories were: grass hays, legume hays, complete-pelleted legume hay diet, complete-pelleted cereal hay diet and complete-pelleted grain diet.

In each digestion trial, diets were fed to four or six mature horses or ponies. During adaptation periods which lasted 19 to 21 days, animals were housed in a barn at a temperature of 15 to 20°C but were allowed voluntary exercise of 6 hours daily in a packed clay paddock. Collection periods were a minimum of 4 days duration. Total collections were made using wooden metabolic crates which allowed the separate collection of feces and urine. During collections, animals were fed at maintenance or 85% of voluntary feed intakes and were allowed to drink water (temperature 5 to 10°C) to satiety 2 to 4 times daily. All horses received regulated amounts (15 to 30 g) of iodized salt daily. Total feed intake, fecal and urinary output were measured daily. Subsamples of feed, feces and urine were also taken daily. Fecal composites were based on 5% daily fecal dry matter output.

Dry matter, energy, crude protein and acid detergent fiber (ADF) content of feed and fecal samples were determined by AOAC methods. Mineral concentrations were determined on acid digests of feed and feces. Calcium content was quantitated by atomic absorption methods and phosphorus by a colorimetric method based on the production of phosphomolybdate.

Statistical methods included analysis of variance of unbalanced data, correlation analysis, linear and stepwise regression analyses. Mean comparisons were made using Tukey's procedure. The percentage of total water excreted in urine and feces was calculated from weight-scaled data. Insensible water loss (%) was calculated as 100 - (% fecal water + % urinary water). Fecal:urinary water ratios were calculated from weight-scaled data.

RESULTS AND DISCUSSION

The nutrient composition and DM digestibilities of diets are given in Table

1. The grass hays were low in crude protein but high in ADF content. Values for these nutrients as well as digestible energy, calcium and phosphorus were typical for locally grown grass, cereal and legume hays. The DM digestibility and digestible energy content of the grass hays were typical for these feeds but lower ($P<.05$) than for the other diets.

Feed and water intake, fecal moisture content, urinary and fecal water output are given in Table 2. Variation has been observed in fecal moisture content between ponies and horses. Since most ponies used here were crossbreds (pony X light horse), no attempt was made to isolate breed effects. Because water intake by horses may depend on body weight and DM intake, the data were corrected to 100 kg BW or per kilogram DM intake. Total water intake was considered to be free and feed water. Feed water was less than 3% of this total. Metabolic water, or water produced by digestion, can contribute up to 270 ml/kg forage DM or about 10% of total water intake but could not be computed from available data. Total urinary water was taken as total urine volume although urine solids may contribute up to 10% of urine volume.

Horses fed grass or legume hays drank more water ($P<.05$) than horses fed complete pelleted feeds irrespective of main ingredient (Table 2). Our data partially support the suggestion that "bulkier" forages increase water requirements compared to more digestible hays. Horses fed complete pelleted diet based on alfalfa hay drank less water than horses fed the poorly digestible grass hays. However, water intake by horses fed either unpelleted grass or legume hays was nearly identical. Fiber content may have contributed to the different water intakes of horses fed pelleted versus long hays.

Daily water consumption (Y, liters/d) depended on DM intake (X, kg/d) in the relationship, $Y = -1.84 + 3.52\ X$ ($R^2 = .71$). This equation indicates

that 3.52 liters of water are consumed for each kilogram of DM intake (0.35 gallons per pound of dry feed) and agrees with the 2-4 liters water/kg DM intake (0.2 to 0.4 gallons/pound DM intake) predicted in 1978 NRC guidelines. Diet type modified absolute water intake. Horses drank 3.2 liters water/kg DM intake of grass and legume hays but only 2.0 liters water/kg DM intake of complete-pelleted grain diet (Table 2). In studies by others, horses fed all roughage diets drank 3.6 liters water/kg DM but only 2.9 liters water/kg DM when fed roughage-grain diets. Furthermore, water consumption (Y, liters/d) was not only related to DM intake but could be predicted from ADF intake (X, kg/d) according to the equation, $Y = 3.47 + 6.97\ X$ ($R^2 = .65$).

The percentage of water recovered in feces and urine depended on diet (Table 3), yet the quantity of water excreted by these routes depended on diet and water intake (Table 2). Total amounts of urine excreted by horses fed legume hays was higher ($P<.05$) than when other diets were fed (Table 2), but the proportion of water intake excreted in urine when alfalfa was fed did not differ to other feeds (Table 3). Horses fed grass hays voided the most fecal water (Table 2), but had low urine production relative to water intake (Table 3). Horses fed complete pelleted grain diets voided only small amounts of fecal water (Table 2) indicating that these diets produced dry feces.

Fecal water output (Y, liters/d) depended on fecal DM output (X, kg/d) in the relationship, $Y = -2.44 + 4.28\ X$ ($R^2 = 0.86$). By comparison, daily urine production (Y, liters/d) depended on total water intake (TWI, liters/d), fecal water excretion (FWE, liters/d) and crude protein intake (CPI, kg/d) and was described in the equation, $Y = -0.22 + 0.57\ TWI - 0.61\ FWE + 1.33\ CPI$ ($R^2 = 0.81$). The partial R^2 for water intake, fecal water excretion and crude protein intake in this equation was .146, .225 and .441, respectively. Neither

calcium nor phosphorus intake affected daily urine production.

Fecal moisture content was poorly corelated to specific nutritional components but showed the highest associations to ADF intake (r = .62), digestible energy content (r = -.62) and DM digestibility (r = -.55). Fecal moisture content (Y, %) was related to digestible energy content (X, Mcal/kg DM) by the equation, $Y = 90.0 - 7.17 X$ ($R^2 = .38$) and to DM digestibility (X, %) by the equation, $Y = 89.3 - 0.31 X$ ($R^2 = .30$). This indicates that as the DE content increases, feces become drier. This is consistent with reports that diets high in oats produce dry feces in horses. Thus, the complete pelleted grain diet produced the driest feces and had the lowest voluntary water intakes. Grass hays which had a low DE content (Table 1) produced feces with 10 percentage units more moisture (Table 2).

Urine output may depend on diet especially sodium or salt intake. Yet, recent studies show that salt intake does not affect water intake or urine output by ponies. Crude protein intake, however, may be important. Although high mineral and protein intakes can elevate fecal water content, neither calcium nor phosphorus intake had a significant statistical relationship to fecal water output in the present study.

Insensible water loss i.e. water lost by respiring and by sweating, was estimated at 14 to 24% (Table 3). Others have reported that excretion patterns of horses fed a timothy-alfalfa hay diet were: 20% in urine, 57% in feces and 23% as insensible losses. Evaporative water losses of between 30 to 40% of total water consumption were estimated for horses fed alfalfa hay.

Feces are reported to be the main route of water excretion by horses, but recent studies have shown that horses fed alfalfa hay excrete water primarily in urine. Diet influenced fecal:urinary water ratios. Fecal:urinary water

ratios of horses fed grass hays were 2.0, but were 0.5 to 0.7 for legume hays and complete pelleted diets based on alfalfa or grain (Table 3). Horses fed pelleted cereal hay diets voided equal amounts of water by both routes. The fecal:urinary ratio indicates the excretory pattern of consumed water. A high ratio indicates most of the water is excreted in feces or conversely retained in the gut. A low ratio implies water is first absorbed then is primarily excreted in urine.

Hay-fed horses retained substantially more water in the lower gut than those fed compound or pelleted feeds. On this basis, diets containing moderate amounts of grass hay have been promoted for endurance horses as a method of increasing intestinal water and electrolyte reserve. Our data suggest that more water may be retained in colonic intestinal contents when grass hay diets are fed (i.e. a high fecal:urinary ratio). However it contradicts the assumption that grass hay is superior to legume hay in promoting water retention since water intake and water retention were identical in horses fed grass or legume hay. Therefore, alfalfa hay is as effective as brome in keeping horses "hydrated".

Passage of digesta through the gut depends on ample intestinal water. Regular and adequate water intake is always stressed as a method to prevent intestinal impactions when highly fibrous and poorly digested forages such as cereal hays are fed to horses. This advice is supported by the present data. Fecal water excretion depends on fecal DM content which implies that more water is retained as indigestible feed residues increase. The coarse structural components of forage may attract water in a sponge-like effect thereby increasing colonic water content. Conversely, horses fed poorly digested diets and given insufficient water would be expected to have drier,

intestinal contents which could cause intestinal impactions.

CONCLUSIONS AND IMPACT

1. The voluntary water intake by idle horses fed at maintenance and housed at 15 to 20°C ranged from 2.0 to 3.3 liters/kg DM feed. Mature horses need at least 13.5 to 22.8 liters water (3 to 5 gallons) daily but the amount needed depends on feed intake and type of diet.

2. Horses fed long hays (grass or alfalfa) drink more water than horses fed processed feeds (grain, alfalfa pellets). Generally, horses overwintered in Saskatchewan are fed long hay and need more, not less, free water to maintain normal bowel movement. Snow is not a good water substitute for horses.

3. Horses fed alfalfa hay produce more urine which increases the bedding required for stabled horses fed high legume diets.

4. Concentrated urine is a vital component in pregnant mare's urine (PMU) production. Our data confirm that grass hay-grain diets are likely ideal for PMU conditions. These diets reduce urine production (i.e. increase urine concentration) while decreasing the desire for free water.

5. From a veterinary standpoint, diet must be controlled when treating horses with kidney or gut disorders and when selecting a drug regimen. Some drugs are excreted via the gut; others through urine. Diets such as alfalfa hay could decrease effectiveness of drugs excreted by the urinary route by increasing the excretory rate through an increase in urinary volume produced.

Table 1. Description and composition of feeds used (dry matter basis)

Feed	Form	No.*	Dry matter digestibility	Nutrient Composition				
				Crude protein	ADF	Calcium	Phosphorus	Digestible energy
			%	%	%	%	%	Mcal/kg
Grass hay	Long, chopped	12	47.4^{d}	8.6^{c}	44.7^{a}	0.44^{c}	0.14^{c}	1.92^{d}
Legume hay	Long, pellets	7	62.0^{b}	18.8^{a}	33.4^{bc}	1.50^{a}	0.22^{bc}	2.56^{bc}
Complete feed	Pellets							
Legume hay (>75%)		10	63.3^{b}	15.8^{b}	26.4^{c}	1.01^{b}	0.58^{a}	2.78^{b}
Grain (>55%)		4	71.2^{a}	17.7^{ab}	17.1^{d}	1.39^{a}	0.63^{a}	3.10^{a}
Cereal hay (>75%)		6	57.2^{c}	16.5^{ab}	31.2^{bc}	0.43^{c}	0.29^{b}	2.44^{c}

* Digestion trials were conducted on each feed using 4 to 6 horses or ponies for total collections of 4 to 7 days.

a-d Values within a column with a different superscript are different ($P<.05$).

Table 2. Water intake, urine and fecal water production by horses fed various diets

Feed	Dry matter intake	Water intake	Urine	Fecal water	Water intake	Urine	Fecal water	Fecal moisture
	(kg/100 kg Wt)	(liters/100 kg Wt)			(liters/kg DM intake)			(%)
Grass hay	1.55^{ab}	4.96^{a}	1.35^{b}	2.73^{a}	3.21^{a}	0.88^{c}	1.74^{a}	76.0^{a}
Legume hay	1.67^{a}	5.47^{a}	2.55^{a}	1.72^{b}	3.26^{a}	1.52^{a}	1.01^{bc}	72.1^{b}
Complete feed								
Legume hay	1.46^{b}	3.75^{bc}	1.66^{b}	1.21^{c}	2.56^{bc}	1.12^{bc}	0.83^{cd}	69.1^{c}
Cereal hay	1.40^{b}	4.06^{b}	1.80^{b}	1.68^{b}	2.86^{ab}	1.26^{ab}	1.20^{b}	73.6^{b}
Grain	1.36^{b}	2.72^{c}	1.53^{b}	0.78^{c}	2.00^{c}	1.13^{bc}	0.58^{d}	66.4^{d}
SEM[e]	0.02	0.12	0.07	0.07	0.06	0.04	0.04	0.4

[a-d] Values within a column with different superscripts differ at P<.05.

[e] Standard error.

Table 3. Percentage water excreted in feces and urine, insensible losses and fecal:urinary water ratios

	Urine	Feces	Insensible[a]	Fecal:urinary water ratio
Grass hay	27.2	55.0	17.8	2.00
Legume hay	46.6	31.4	22.0	0.66
Complete feed				
Legume hay	44.2	32.4	23.5	0.71
Cereal Hay	44.3	41.4	14.3	0.95
Grain	56.2	28.7	15.1	0.51

[a] Insensible losses = 100 - (% water in feces + % water in urine).

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